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PROBLEM SUMMARY FOR SF-11-121-106/8132 FOR THE PERIOD 1 JULY 19--ETC(U)
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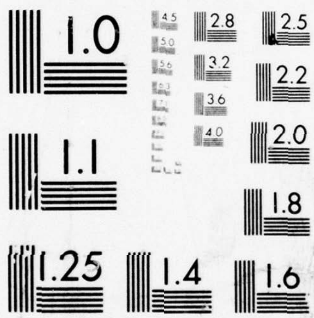

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(6) PROBLEM SUMMARY FOR SF-11-121-106/8132
FOR THE PERIOD 1 JULY 1969 TO 31 DECEMBER 1969, (U)

by
(10) G./Turton
Signal Recognition Division (Code 606)

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CONTENTS

TABLES

ILLUSTRATIONS

1.0 INTRODUCTION

1.1 The Objective is

(C) To develop a combined track-classify algorithm based on state-of-the-art target motion analysis and space-time classification methods. To map the performance envelopes of the algorithm relative to the AN-SQQ-23 sonar system parameters and other active systems as time and manpower permit. To write a proposed technical approach (PTA) to active classification in contemporary sonar systems based on these performance envelopes.

1.2 Background

(C) A recent report by D. G. Olson (Reference 1) outlines rough performance predictions for STARLITE classification method based on detection performance predictions of the AN-SQQ-23 sonar system and the Weikhorst geometric constraint equations for the STARLITE classification method. However, the Weikhorst constraints are incomplete because they do not take echo-to-noise ratio into account. It is a fairly safe assumption that an operational STARLITE processor would be sensitive to echo-to-noise ratio which, in turn, is dependent on sonar system parameters, and track geometry. The task which remains is to design a specific operational procedure for using STARLITE information in combination with other sonar outputs in an optimal fashion, and to measure rather than predict its performance.

1.3 Approach

(C) A specific classification procedure using both STARLITE and target motion information is to be designed and tested. It will be designed using the AN-SQQ-23 PAIR sonar system parameters as a basis for defining available sensor information. It will be tested using computer simulation techniques, incorporating both computer generated target echoes and actual sonar echo sequences from the AN-SQQ-23 PAIR system. The artificial echo data is necessary to maintain parameter control for measuring performance over a wide range of parameter values. Tape recorded sonar echoes, although limited to a fairly restricted range of parameter values, is necessary to lend the necessary degree of credibility to the results.

(C) Most simply stated, target track information will be used to "predict" STARLITE processor outputs. The predicted outputs will be compared with measured STARLITE outputs to determine whether or not a sufficient amount of self-consistency exists to justify making a contact classification. The rationale for combining target motion information with STARLITE clues follows simply from the fact that the STARLITE processor output is heavily dependent on relative track geometry. If the track geometry can be determined through independent measurements (range, bearing, Doppler), much of the ambiguity associated with a STARLITE processor output can be removed. One of the basic problems to be resolved is to determine how many echo returns are necessary to gain a sufficiently accurate track solution based on

the range, bearing, and Doppler measurement accuracy of the sonar system in question. Once this basic comparison scheme is perfected, other classification clues may be added to the decision rule to help improve performance.

1.4 Plans, Milestones

(C) Figure 1 is a program flow chart in which specific tasks are indicated by rectangles and milestones by octagonals. A milestone is defined as a point in the program flow at which the decision must be made to continue, to go back and modify, or to stop and redefine the program. Normally, these are shown following the completion of each task. This does not mean, however, that the task must be carried through to the end before such a decision can be reached. An NUC Technical Note will be written at each milestone point to provide a tangible basis for program evaluation.

(C) At the beginning, the flow diagram consists of four main branches. These are:

I. Data production and collection for performance mapping.

II. Development and performance mapping of a STARLITE processor for the AN-SQQ-23 sonar system.

III. Target motion algorithm selection, modification, and performance mapping.

IV. Display development for data monitoring and operator clue evaluation.

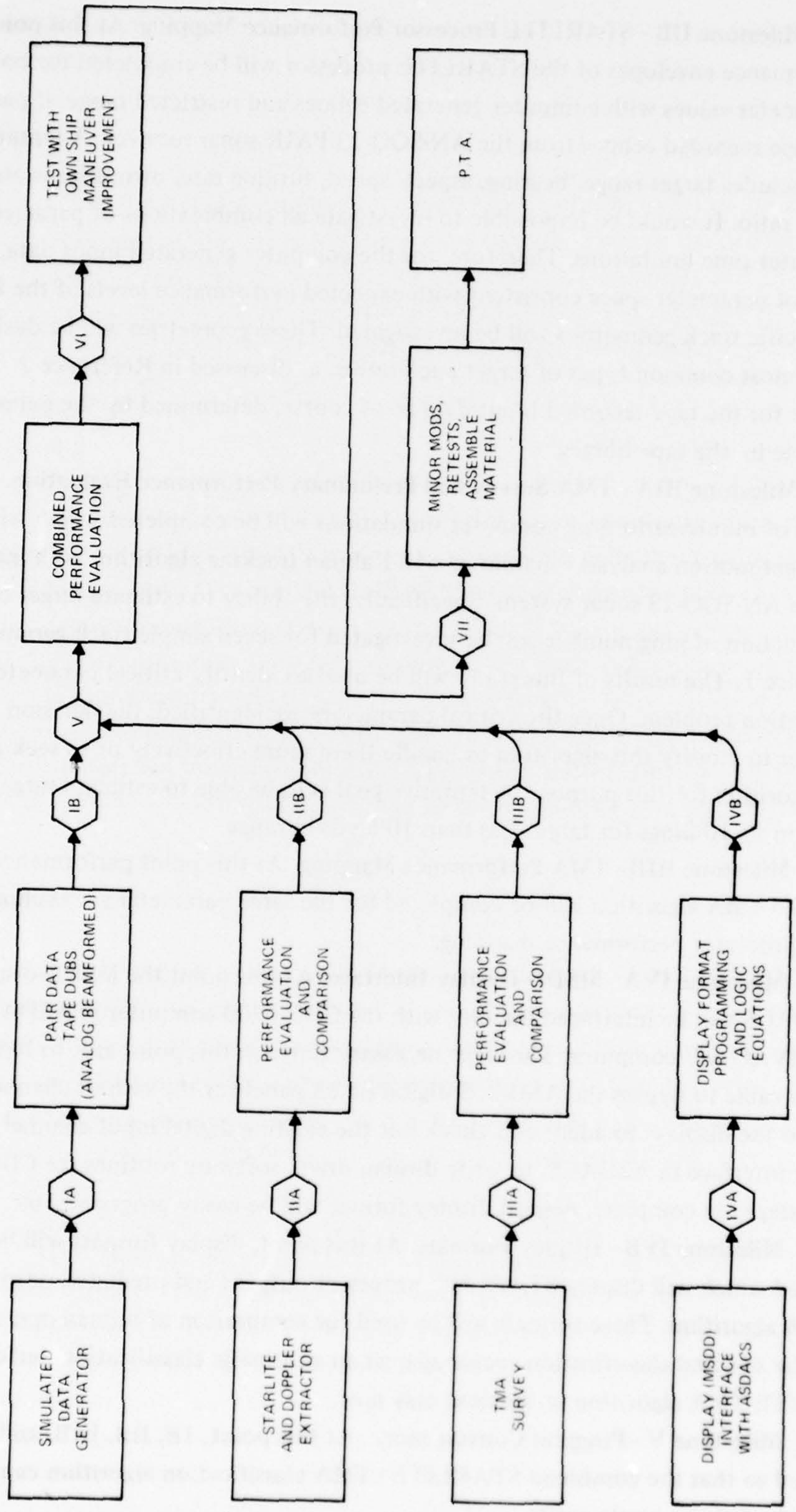
These four branches converge to a single branch in which an algorithm is assembled to use both STARLITE and TMA information to classify the contacts. The output of this algorithm is to be both an automatic classification decision and a graphical data display for operator clue evaluation.

The following text is a list of milestones and explanations.

(C) **Milestone IA - Computer Generated Echoes.** At this point, all software programs for supplying computer generated echoes with tape recorded reverberation will be complete and debugged. Effects due to variable target range, speed, aspect, turning rate, own ships motion and beam-forming will be incorporated into these echoes. The tape recorded reverberation will be taken from USS Glennon dual dome array (PADLOC II). This data will be filtered through digital filter in the ASDAC System.

(C) **Milestone IB - Tape Recorded Echoes.** At this point all tape recorded echo data from the AN-SQQ-23 PAIR receiver will be in-house and evaluated for quality; i.e., whether or not spurious frequencies or other effects such as overclipping are present that would seriously impair data usage.

(C) **Milestone IIA - STARLITE Software Completion.** At this point software will be complete and debugged for a STARLITE processor algorithm. Preliminary performance checks will also be completed to insure that the programs are efficiently composed. Since this algorithm will later be used for many repeated runs in a monte-carlo type performance evaluation, it is essential that it use as little computer time as possible.



(C) Figure 1. Program Flow Chart for CY-70.

(C) **Milestone IIB - STARLITE Processor Performance Mapping.** At this point a mapping of performance envelopes of the STARLITE processor will be completed for both a wide range of parameter values with computer generated echoes and restricted range of parameter values with tape recorded echoes from the AN-SQQ-23 PAIR sonar receiver. A tentative parameter list includes target range, bearing, aspect, speed, turning rate, own ships motion, and echo-to-noise ratio. It would be impossible to investigate all combinations of parameter values due to computer time limitations. Therefore, for the computer generated input data, only certain areas of parameter space consistent with expected performance levels of the PAIR receiver for specific track geometries will be investigated. These geometries will be designed, based on the most common types of target encounters, as discussed in Reference 2. The parameter space for the tape recorded input data is, of course, determined by the parameter values available in the tape library.

(C) **Milestone IIIA - TMA Survey and Preliminary Performance Evaluation.** At this point a series of monte-carlo type computer simulations will be completed which will demonstrate the target motion analysis capabilities of a Kalman tracking algorithm with inputs available from the AN-SQQ-23 sonar system. Specifically, the ability to estimate target course and speed as a function of ping number will be investigated for seven simple track geometries taken from Reference 1. The results of this study will be used to identify critical parameters in the course estimation problem. Once the critical parameters are identified, the decision can be made whether to modify this algorithm to handle them more effectively or to seek another candidate algorithm for this purpose. A tentative goal is to be able to estimate target course within $\pm 10^\circ$ in 5–10 pings for target less than 10 Kyds in range.

(C) **Milestone IIIB - TMA Performance Mapping.** At this point performance mapping of the selected TMA algorithm will be completed for the same parameter set as chosen for the STARLITE processor performance mapping.

(U) **Milestone IVA - MSDD Display Interface.** At this point the MSDD display on loan to ASDACS will be interfaced directly with the CDC 1700 computer in ASDACS, bypassing the UNIVAC 667 computer. The steps necessary to reach this point are: to build line drivers and a cable to bypass the ASDACS digital patch panel for the output channel from the CDC 1700 to the display; to adapt and check out the existing digital input channel through the delogger interface in ASDACS; to write display driver software routines for CDC 1700. Once these steps are complete, desired display format will be easily programmable.

(C) **Milestone IVB - Display Formats.** At this point, display formats will be completed and debugged which will display STARLITE processor outputs and predicted outputs generated by the TMA algorithm. These formats will be used for comparison of human operator classification for the selected classification vector against an automatic classification performed by the STARLITE-TMA algorithm in the next task area.

(C) **Milestone V - Program Convergence.** At this point, IB, IIB, IIIB, and IVB must be completed so that the combined STARLITE - TMA classification algorithm can be assembled and evaluated as a single entity.

(C) **MILESTONE VI - Track-Classify Algorithm Evaluation.** At this point the combined STARLITE - TMA classification algorithm will be evaluated on an ROC curve basis, averaged over the track geometries used previously for STARLITE and TMA performance maps. The ROC analysis will be completed for both operator and automatic clue evaluation. A tentative design goal is to classify at 90% with a false alarm rate of 10% within three pings after acquiring a target track.

1.5 Current Status Summary

(C) A simulated sonar echo generation algorithm has been completed for a stationary target and constant velocity-receiving platform. Equations for a nonstationary target and receiving platform with yaw, surge, and sway velocity components have been derived.

(C) The time and frequency-domain implementations of a STARLITE processor have been compared. The frequency-domain processor appears superior when target bearing is inaccurately known and when matched filtering is desirable for processing gain. The time-domain processor has the advantage of being easily implemented and performs well if target bearing could be accurately determined.

(C) Tape-recorded reverberation has been obtained for use with synthetically generated echoes and has been quantitatively evaluated.

(U) A digital display has been partially interfaced directly with the CDC 1700 computer in ASDACS. Further software refinements are needed for general usage.

2.0 AREAS OF EFFORT

2.1 Applied Research

2.1.1 Echo Simulation

The objective of this effort is to develop a computer program to generate simulated submarine echoes for a dual-receiving array active sonar system. This echo generation algorithm will sum the echoes from individual reflectors on the target model (Reference 3), as well as duplicate this spatial beamforming of the SQQ-23 PAIR beamformers (Reference 4). The simulated echoes will include the effects of the following own ship and target motion components: own ship's roll, yaw, surge, sway, and constant velocity along own ship's heading; and target constant velocity and constant turning rate. The above motion components will be resolved into equivalent relative motion between each hydrophone-reflector pair to compute the resultant time delay and Doppler time-scale factor for each echo component.

(C) The target model reported in Reference 5 has been modified to include aspect-dependent shading, documented in Reference 3. The introduction of shading vastly improved the target model, as is evidenced by Figures 2–4. Figure 2 shows the target strength pattern of the unshaded model, and Figure 3 shows that of the shaded model. Figure 4 shows a measured target strength pattern for the USS Nautilus (Reference 6). Note that the difference between the target strength at beam aspect and that at bow or stern aspect is 10 dB for the Nautilus, 9 dB for the shaded model, and 6 dB for the unshaded model. These comparisons verify not only that shading vastly improves the target model, but also that the shaded model is a very reasonable two-dimensional acoustic representation of a submarine.

(C) In addition to the target model, the derivation of the defining equations for the echo simulation algorithm has been completed and documented in Reference 7. The equations define exactly the echoes received at both the forward and aft arrays of a dual array sonar system for (a) the case of a stationary target and quasi-stationary sonar platform and (b) the case of a nonstationary target and sonar platform. The equations for the quasi-stationary case give the echoes as functions of the parameters: range, bearing, aspect angle, own ship constant velocity, and the orientation of the beamformer. Those for the nonstationary case give the echoes as functions of range, bearing, aspect angle, own ship constant velocity, orientation of the beamformer, own ship constant velocity, target constant turning rate and constant velocity, displacement due to roll, period of roll, maximum angular displacement due to roll, displacement due to yaw, period of yaw, maximum angular displacement due to yaw, sway velocity and displacement, and surge velocity and displacement.

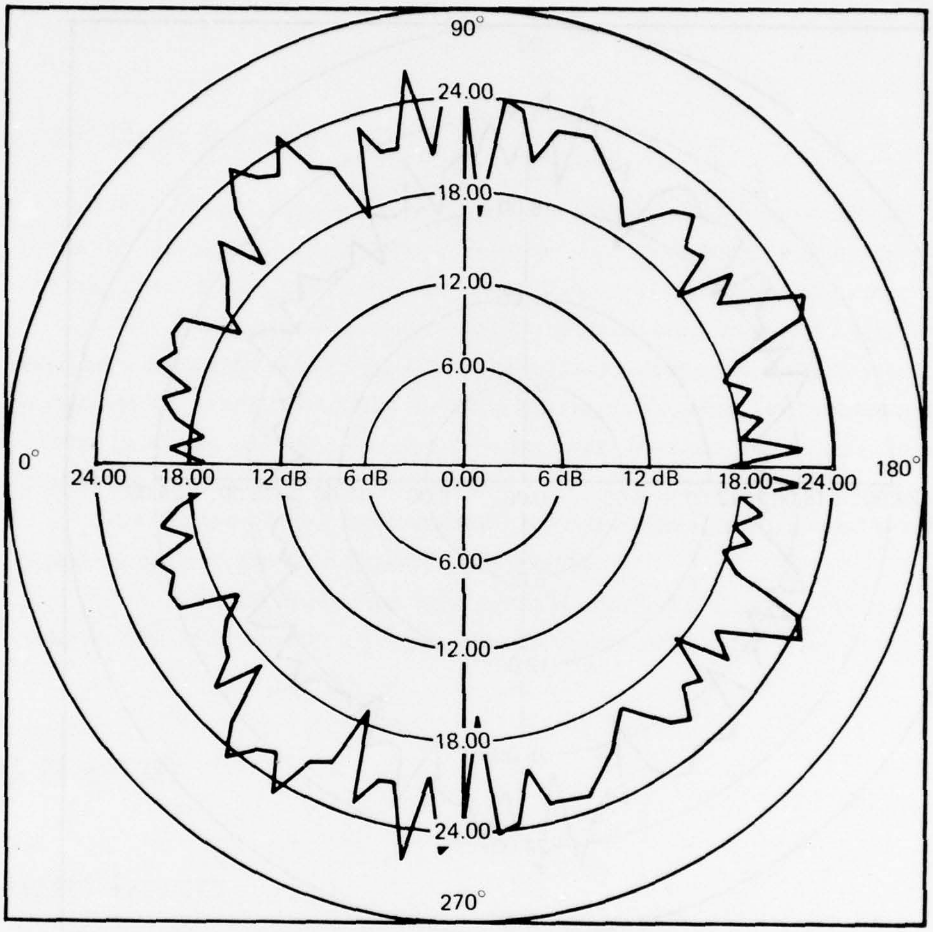
(U) The remaining task in the evolution of the echo simulation algorithm is a sensitivity analysis of the defining equations of the simulated echoes to determine which short-cuts can be taken in the computation of the simulated echoes, and thereby minimize the complexity of the algorithm and its software implementation.

2.1.2 Starlite Processors

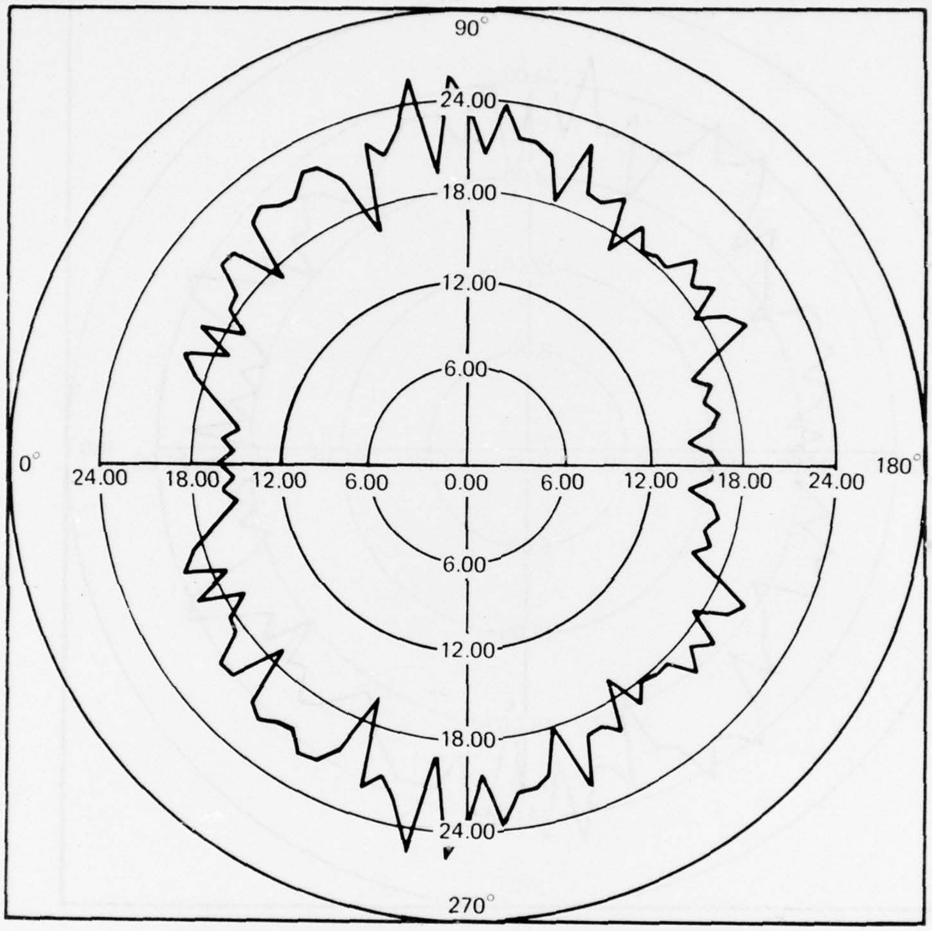
(C) The ultimate goal of this effort is to determine the optimal STARLITE receiver for the AN/SQQ-23 sonar system relative to performance envelopes and processor complexity. The initial effort has been to compare time- and frequency-domain processors (Figure 5) relative to four criteria:

1. Mean absolute error in aspect angle
2. Standard deviation of aspect angle error
3. Mean output correlation peak width at 0.9 maximum peak height
4. Average main-to-secondary peak height ratio
5. Average main peak height.

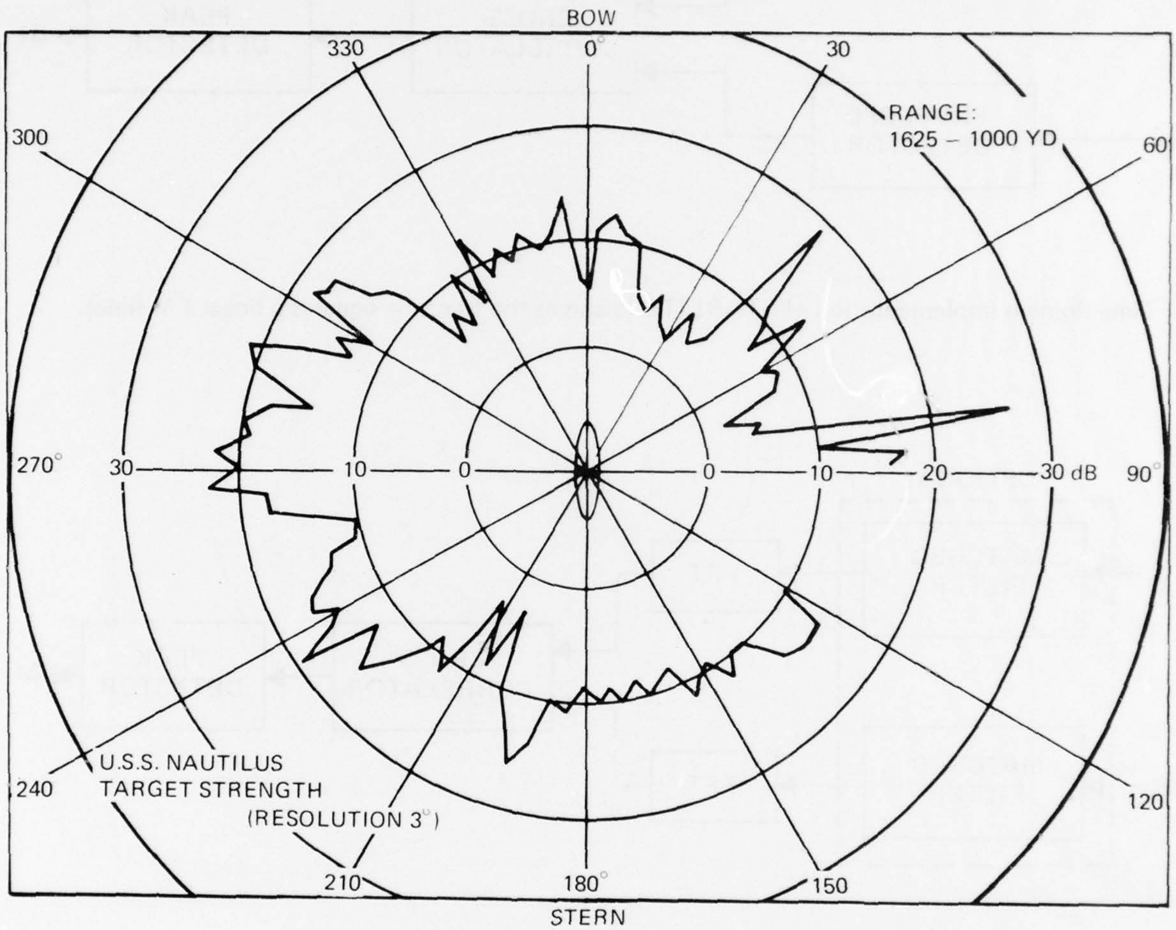
The results are summarized in Table 1.



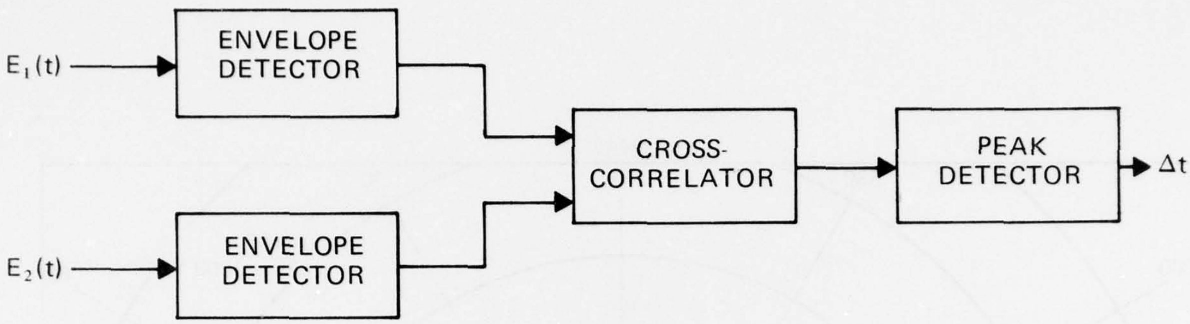
(U) Figure 2. Unshaded model target strength pattern.



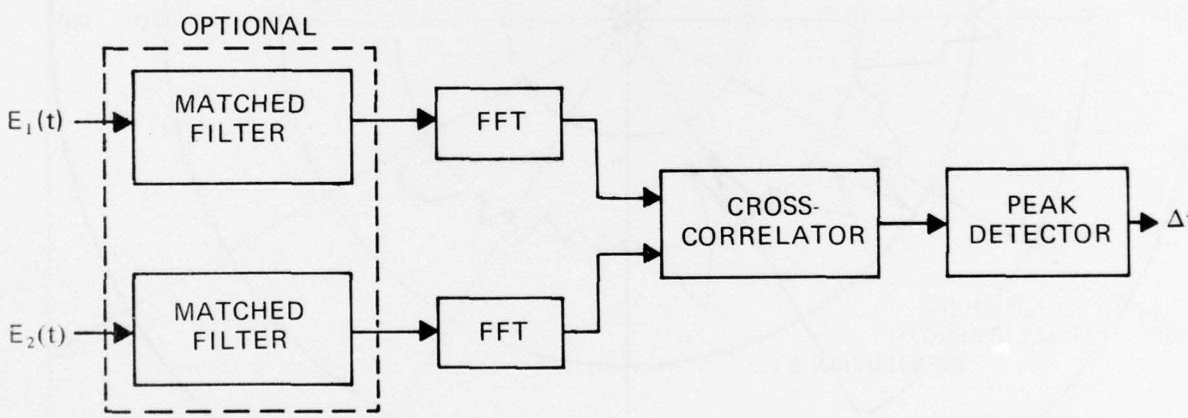
(U) Figure 3. Shaded model target strength pattern.



(C) Figure 4. USS NAUTILUS target strength pattern.



(A) Time-domain implementation of STARLITE (assumes the transmit signal is a linear FM slide).



(B) Frequency-domain implementation of STARLITE (assumes the transmit signal is 'band-limited').

(C) Figure 5. Time- and Frequency-domain Implementations of STARLITE Processors.

(C) TABLE 1. STATISTICAL COMPARISON OF TIME- AND FREQUENCY-DOMAIN PROCESSORS

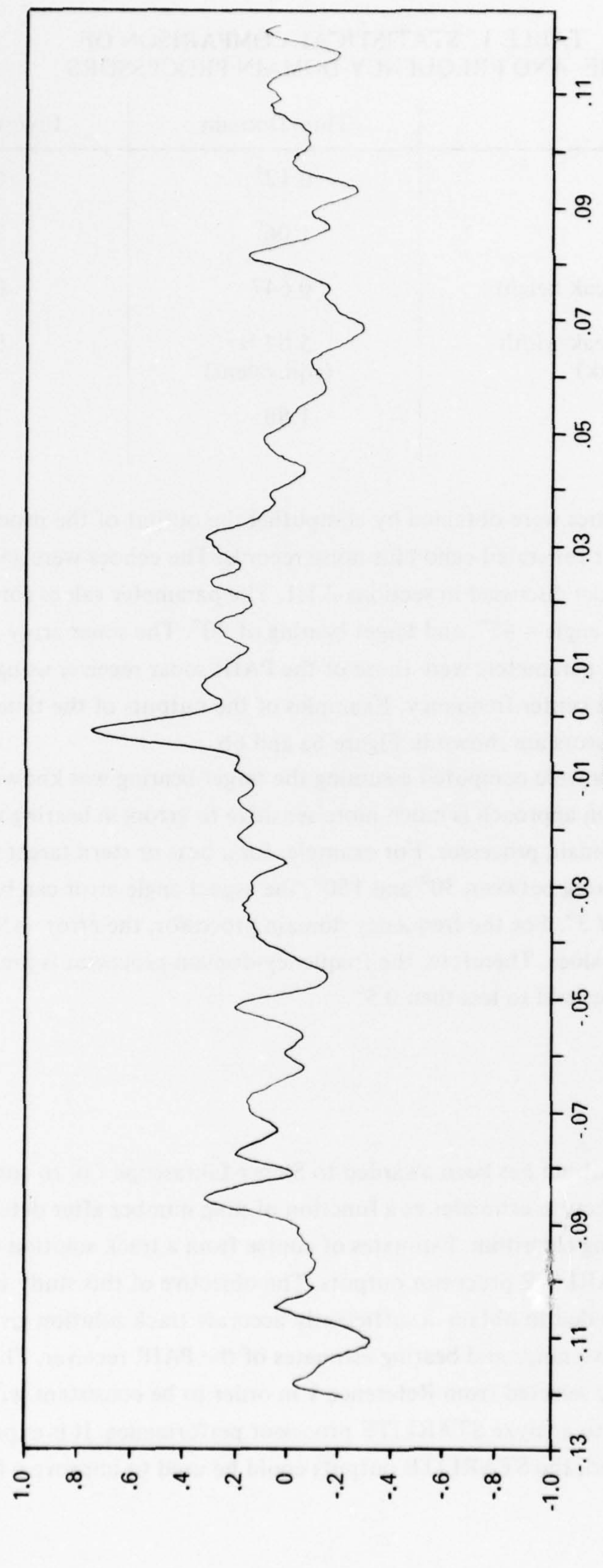
	Time Domain	Frequency Domain
Mean |error| of $\hat{a}$	0.12°	0.856°
Standard deviation $\hat{a}$	1.06°	3.0°
Mean main correlation peak height	0.647	0.919
Mean main correlation peak width (0.9 down, 0.707 no work)	5.84 Hz (equivalent)	9.975 Hz
Mean main-to-secondary correlation peak ratio	1.88	1.215

(C) These statistics were obtained by computing the output of the processors for an ensemble of 36 computer generated echo plus noise records. The echoes were generated from the stationary target model discussed in sections 2.1.1. The parameter values for these trials were: R = 5 Kyd, aspect angle = 45°, and target bearing of 90°. The sonar array geometry and transmit pulse waveform parameters were those of the PAIR sonar receiver using a 161 milli-second FM slide at 5 Khz center frequency. Examples of the outputs of the time- and frequency-domain processors are shown in Figure 6a and 6b.

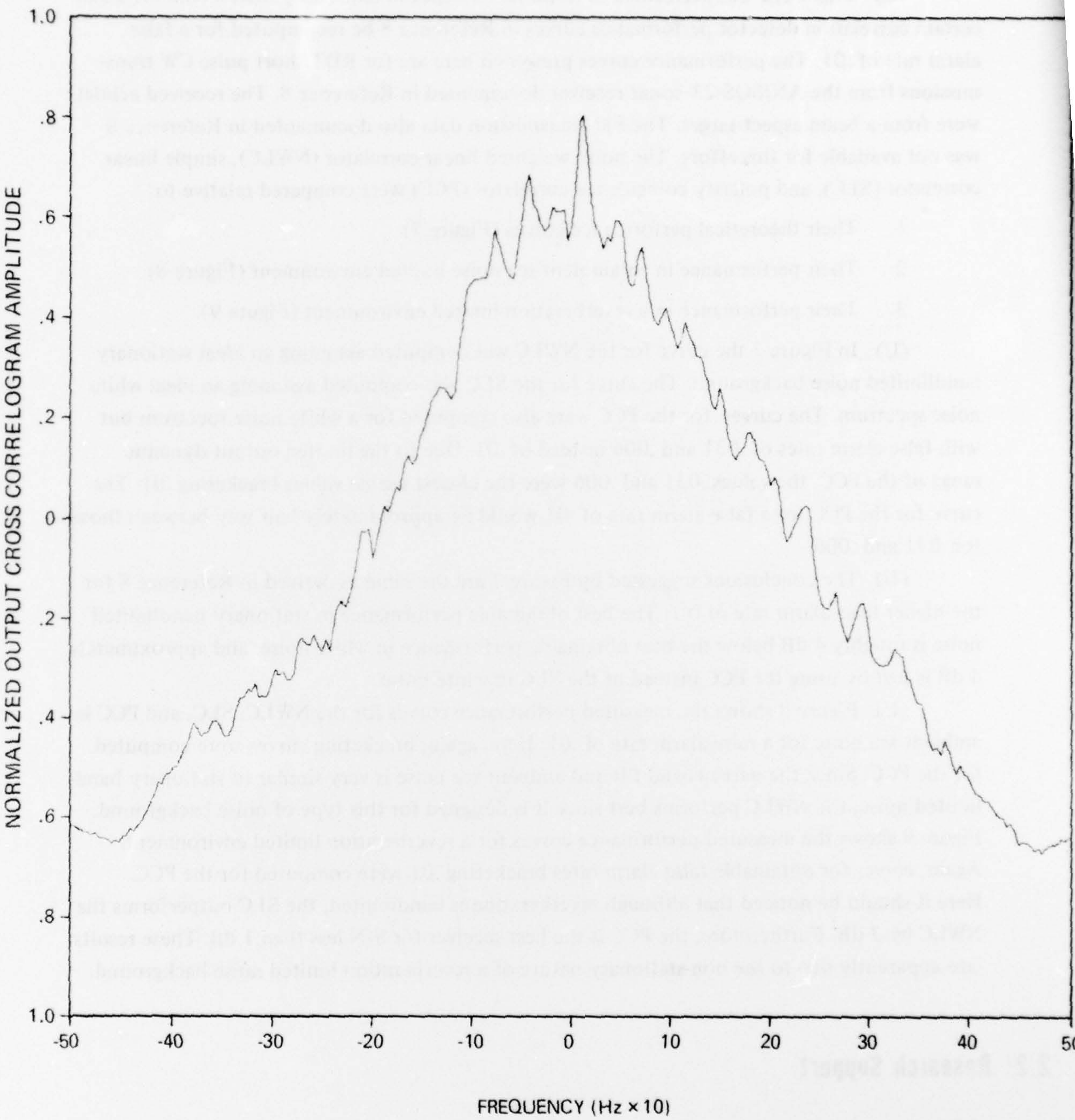
(C) These results were computed assuming the target bearing was known exactly. However, the time-domain approach is much more sensitive to errors in bearing measurements than is the frequency-domain processor. For example, for a bow or stern target at a range of 10 Kyds and relative bearing between 30° and 150°, the aspect angle error can be as high as 27° for a bearing error of 3°. For the frequency-domain processor, the error is less than 2° for the same parameter values. Therefore, the frequency-domain processor is preferable unless the bearing error could be held to less than 0.5°.

2.1.3 Tracking Study

A small study contract has been awarded to Singer-Librascope Co. to compute expected error variances in target course estimates as a function of ping number after detection for the Singer-Librascope tracking algorithm. Estimates of course from a track solution can be used to resolve ambiguity in STARLITE processor outputs. The objective of this study is to determine how many echoes are needed to obtain a sufficiently accurate track solution given the predicted accuracies of the active range and bearing estimates of the PAIR receiver. The test tracks selected for analysis were selected from Reference 1 in order to be consistent with previous efforts within Code 606 to analyze STARLITE processor performance. It is expected that once a contact is classified, the STARLITE outputs could be used to improve a fire control solution.



(C) Figure 6(a). Simulated Output Correlogram for the Time-Domain Implementationof STARLITE: R = 5 Kyd, $\phi = 45°$, $\beta = 90°$, S-N-R = 0 dB.



(C) Figure 6(b). Simulated Output Correlogram for the Frequency-Domain Implementation of STARLITE: $\phi = 45°$, R = 5 Kyd, $\beta = 90°$, S-N-R = 0 dB.

2.1.4 Detector Performance Comparison

(C) This work was performed in response to a special request by SHIPS (OOVIC) that certain correlation detector performance curves in Reference 8 be recomputed for a false alarm rate of .01. The performance curves presented here are for RDT short pulse CW transmissions from the AN/SQS-23 sonar receiver documented in Reference 8. The received echoes were from a beam aspect target. The FM transmission data also documented in Reference 8 was not available for this effort. The noise weighted linear correlator (NWLC), simple linear correlator (SLC), and polarity coincidence correlator (PCC) were compared relative to:

1. Their theoretical performance curves (Figure 7).
2. Their performance in an ambient sea noise limited environment (Figure 8).
3. Their performance in a reverberation limited environment (Figure 9).

(U) In Figure 7 the curve for the NWLC was computed assuming an ideal stationary bandlimited noise background. The curve for the SLC was computed assuming an ideal white noise spectrum. The curves for the PCC were also computed for a white noise spectrum but with false alarm rates of .031 and .006 instead of .01. Due to the limited output dynamic range of the PCC, the values .031 and .006 were the closest usable values bracketing .01. The curve for the PCC for a false alarm rate of .01 would lie approximately half way between those for .031 and .006.

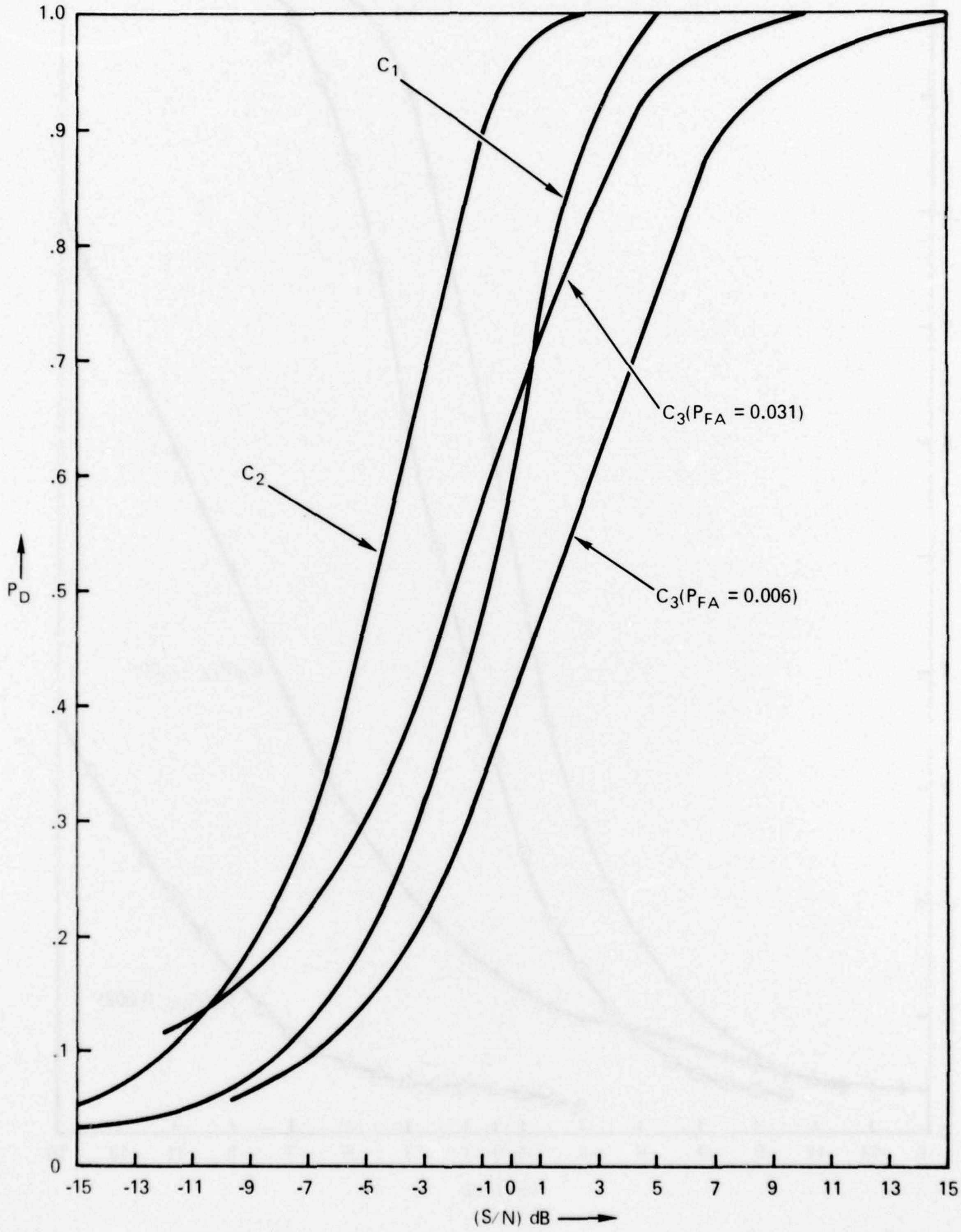
(U) The conclusions suggested by Figure 7 are the same as derived in Reference 8 for the higher false alarm rate of 0.1. The best obtainable performance in stationary bandlimited noise is roughly 4 dB below the best obtainable performance in white noise, and approximately 4 dB is lost by using the PCC instead of the SLC in white noise.

(U) Figure 8 shows the measured performance curves for the NWLC, SLC, and PCC in ambient sea noise for a false alarm rate of .01. Here, again, bracketing curves were computed for the PCC. Since the narrowband filtered ambient sea noise is very similar to stationary bandlimited noise, the NWLC performs best since it is designed for this type of noise background. Figure 9 shows the measured performance curves for a reverberation limited environment. Again, curves for obtainable false alarm rates bracketing .01 were computed for the PCC. Here it should be noticed that although reverberation is bandlimited, the SLC outperforms the NWLC by 3 dB. Furthermore, the PCC is the best receiver for S/N less than 1 dB. These results are apparently due to the non-stationary nature of a reverberation limited noise background.

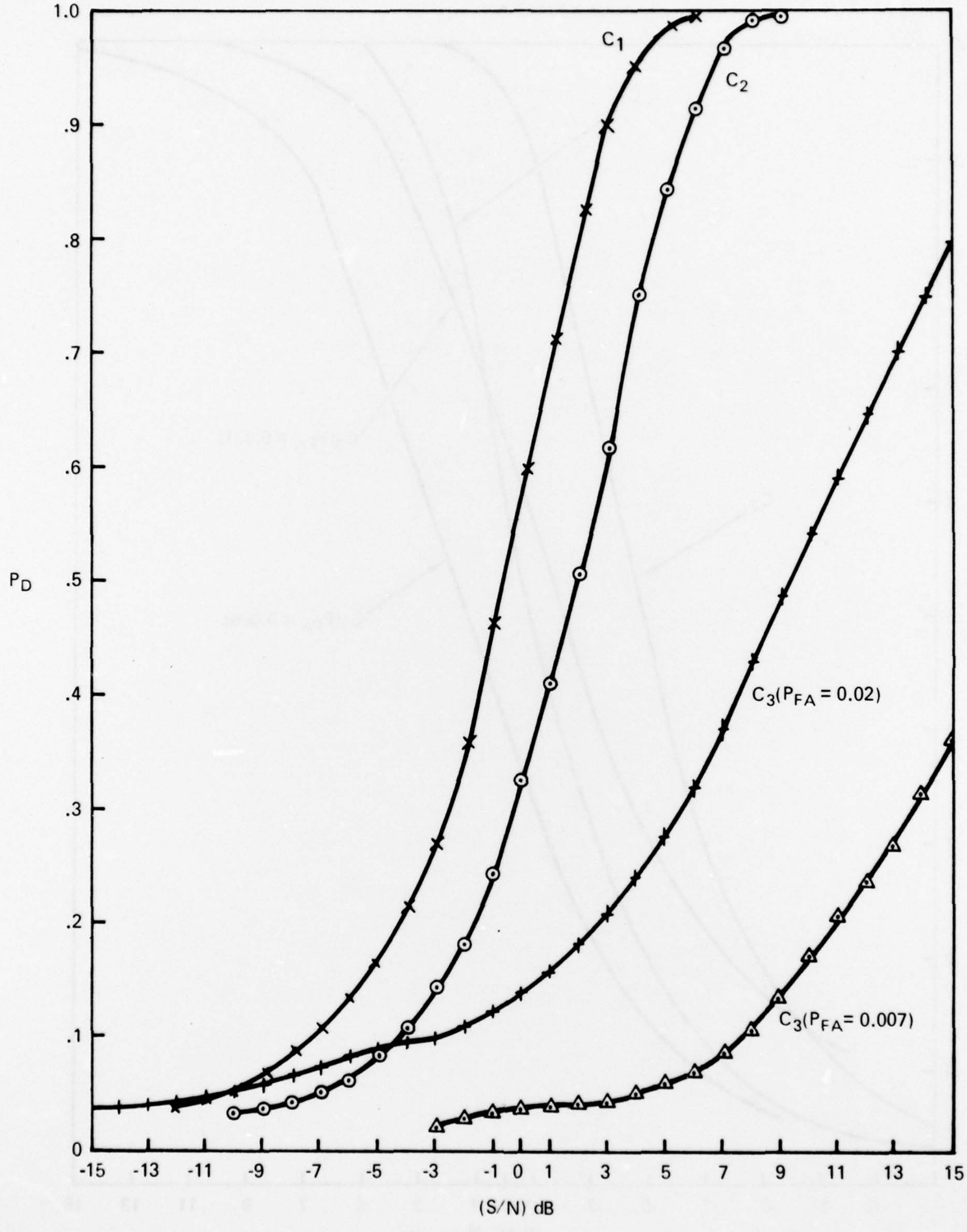
2.2 Research Support

2.2.1 Data Collections

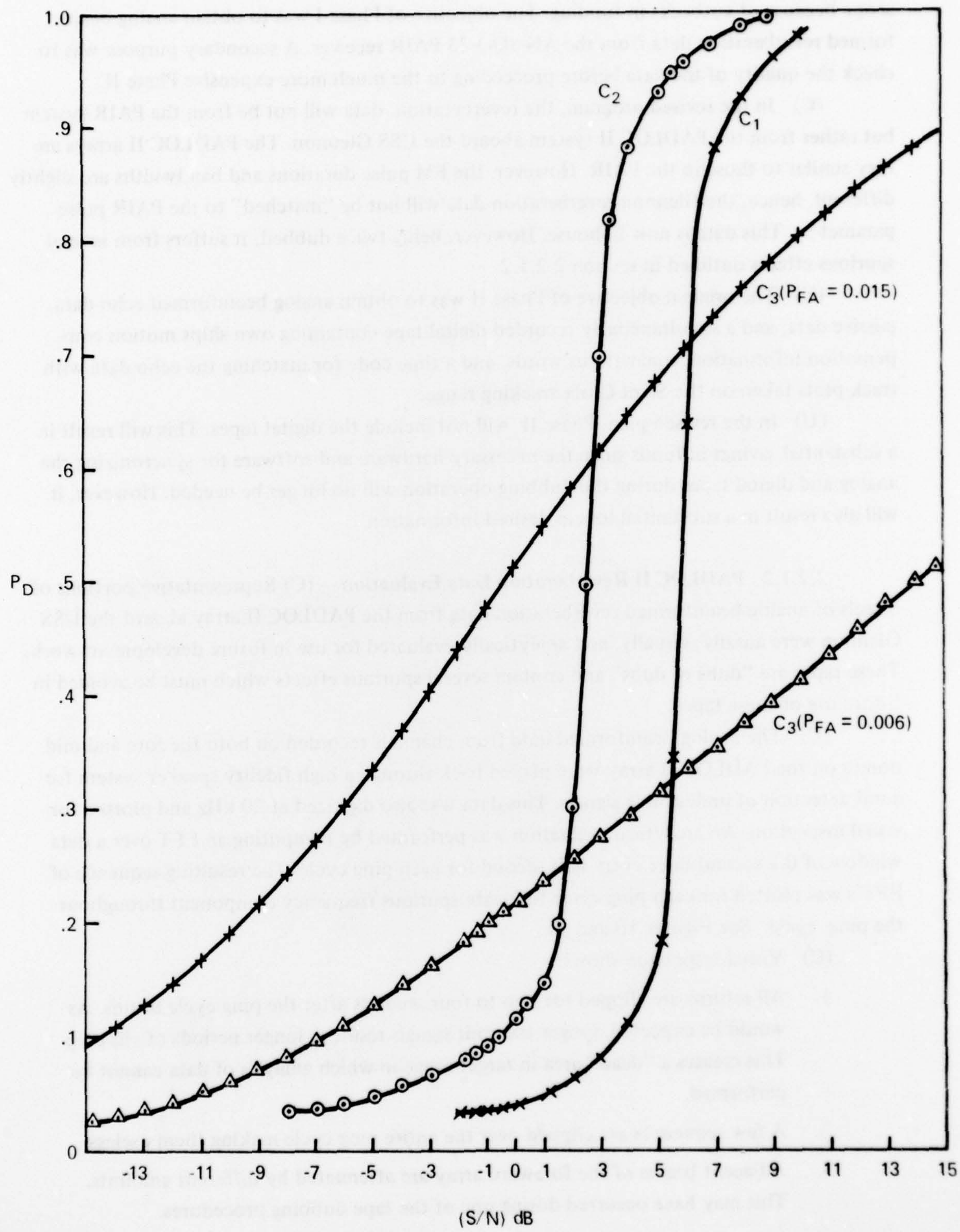
2.2.1.1 Current Status – (C) The data collection plan outlined in the previous progress report consisted of two phases which have subsequently been greatly reduced in



(C) Figure 7. Theoretical Performance Curves for the Noise Weighted Correlator (C_1), Simple Linear Correlator (C_2) and Polarity Coincidence Correlator (C_3) for a PFA of 0.01.



(C) Figure 8. Empirical Performance Curves for the NWLC (C_1), SLC (C_2), and PCC (C_3) in an Ambient Sea Noise Limited Background for a PFA of 0.01.



(C) Figure 9. Empirical Performance Curves for the NWLC (C_1), SLC (C_2), and PCC (C_3) in a Reverberation Limited Background for a PFA of 0.01.

scope because of cutbacks in funding. The objective of Phase I was to obtain analog beamformed reverberation data from the AN-SQQ-23 PAIR receiver. A secondary purpose was to check the quality of the data before proceeding to the much more expensive Phase II.

(C) In the revised program, the reverberation data will not be from the PAIR system but rather from the PADLOC II system aboard the USS Glennon. The PADLOC II arrays are very similar to those in the PAIR. However, the FM pulse durations and bandwidths are slightly different, hence, the Glennon reverberation data will not be "matched" to the PAIR pulse parameters. This data is now in-house. However, being twice dubbed, it suffers from several spurious effects outlined in section 2.2.1.2.

(C) The original objective of Phase II was to obtain analog beamformed echo data, passive data, and a simultaneously recorded digital tape containing own ships motion compensation information, sonar status words, and a time code for matching the echo data with track plots taken on the Saint Croix tracking range.

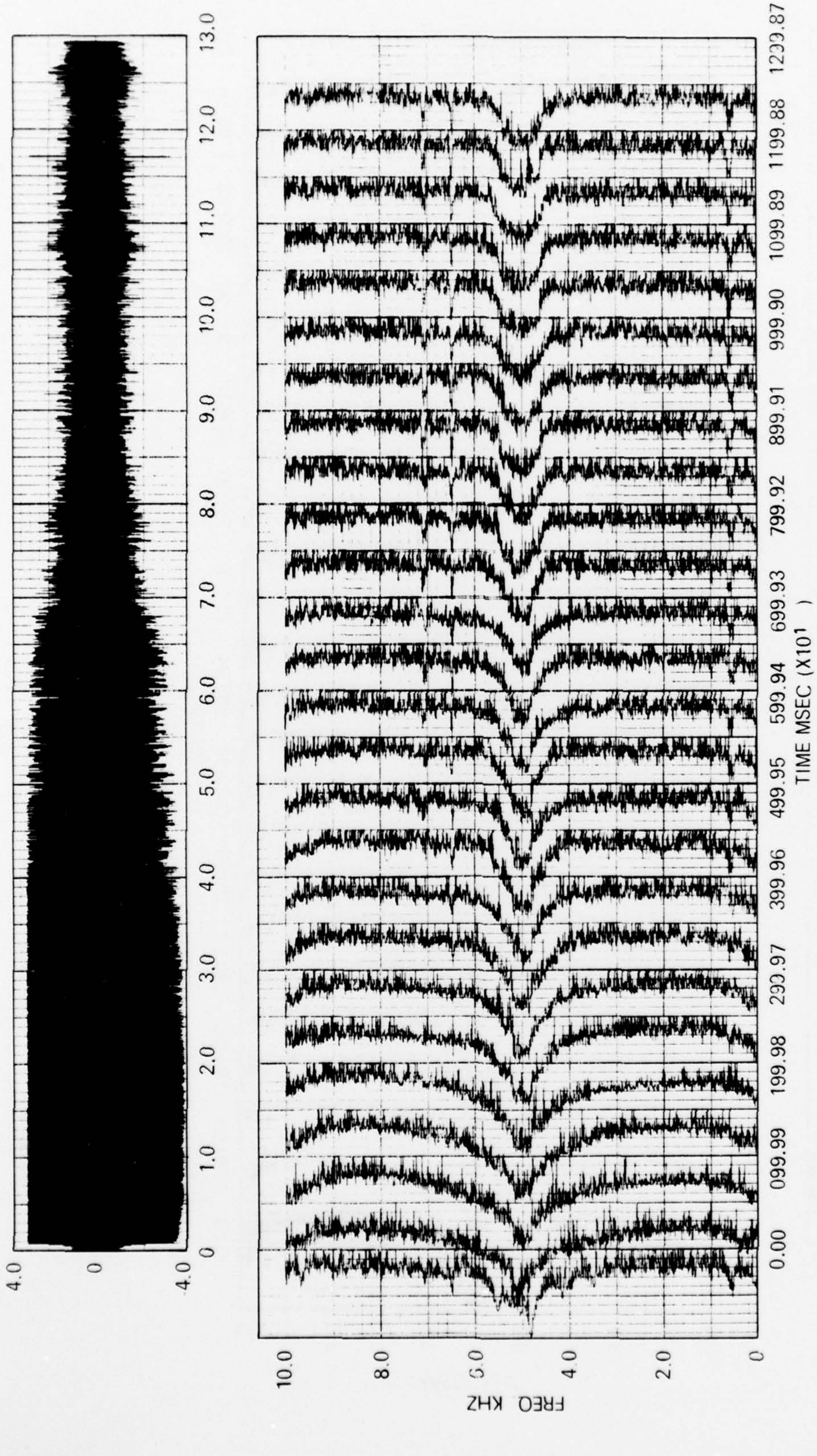
(U) In the revised plan, Phase II will not include the digital tapes. This will result in a substantial savings in funds since the necessary hardware and software for syncronizing the analog and digital tapes during the dubbing operation will no longer be needed. However, it will also result in a substantial loss in desired information.

2.2.1.2 **PADLOC II Reverberation Data Evaluation** – (C) Representative portions of 5 reels of analog beamformed reverberation data from the PADLOC II array aboard the USS Glennon were aurally, visually, and analytically evaluated for use in future development work. These tapes are "dubs of dubs" and contain several spurious effects which must be avoided in future use of these tapes.

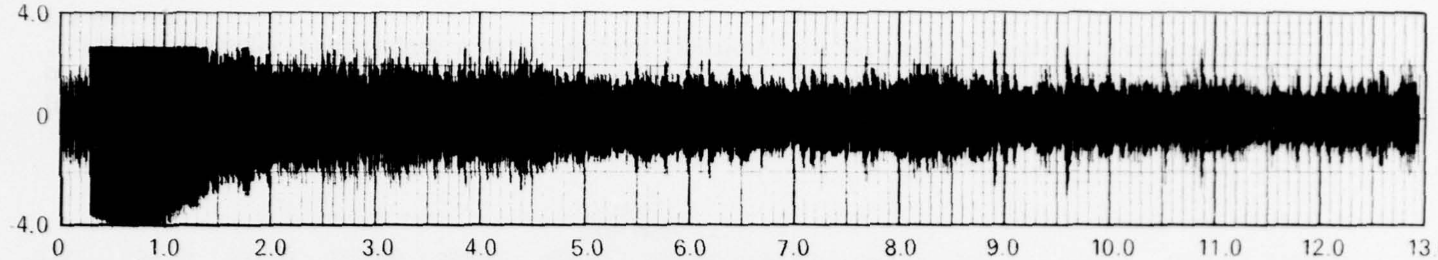
(C) The analog beamformed data from channels recorded on both the fore and mid domes on the PADLOC II array were played back through a high fidelity speaker system for aural detection of undesirable signals. This data was also digitized at 20 kHz and plotted for visual inspection. An analytical evaluation was performed by computing an FFT over a data window of 0.1 second once every half second for each ping cycle. The resulting sequence of FFT's was plotted for each ping cycle to locate spurious frequency component throughout the ping cycle. See Figures 10 and 11.

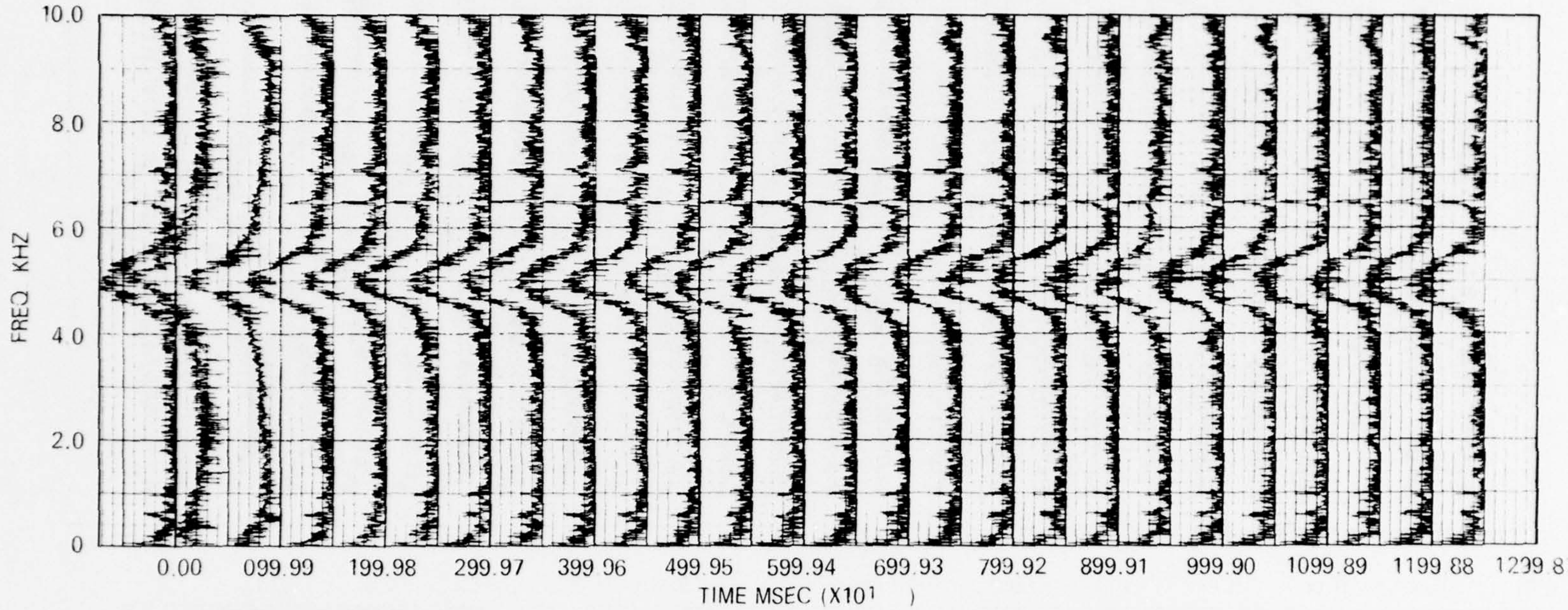
(C) Visual inspection shows:

1. All returns are clipped for two to four seconds after the ping cycle begins. As would be expected, longer transmit signals result in longer periods of clipping. This creates a "dead" area in target range in which analysis of data cannot be performed.
2. A few sequences are clipped over the entire ping cycle making them useless.
3. Adjacent beams of the foreward array are attenuated by different amounts. This may have occurred during one of the tape dubbing procedures.



(C) Figure 10. Upper Graph: Amplitude Versus Time Plot of Digitized Samples from Beam 9 of Fore Dome of PADLOC II Array for One Ping Cycle of Reverberation for a 240 msec 400 Hz FM Upslide Centered at 5 kHz. Lower Graph: Time Sequence of Fast Fourier Transforms for a 0.1 sec Data Window Taken Every 0.5 Seconds.





(C) Figure 11. Upper Graph: Amplitude Versus Time Plot of Digitized Samples from Beam 8, Mid Dome of PADLOC II Array for One Ping Cycle of Reverberation for a 120 msec 400 Hz FM Upslide Centered at 5 kHz. Lower Graph: Time Sequence of Fast Fourier Transforms for a 0.1 sec Data Window Taken Every 0.5 Seconds.

4. Bottom reverberation appears to be present in many of the returns 8 to 10 seconds after commencement of the ping cycle on most of the data. The reverberation appears somewhat more "echo like" than the volume reverberation.

(C) Frequency analysis indicates:

1. Background noise levels are 45 to 54 dB down from the largest frequency component in the passband. This is satisfactory.

2. Spurious frequency component spikes are present at 0.6 kHz, 1 kHz, 6.5 kHz, and 7 kHz. These spikes are generally 12 to 24 dB above the background noise level. These spikes can be eliminated by proper filtering of the data.

2.2.2 ASDACS

2.2.2.1 Current Status

2.2.2.1.1 General Purpose Software – (U) The following routines are general purpose FORTRAN compatible programs and subprograms written for the CDC 1700 computer.

1. (U) PROGRAM STATIS: Computes the mean, variance, probability density function of a given ensemble according to a specified resolution. The density function and the distribution function are given in tabular form and are optionally plotted. (The program uses: FUNCTION XMEAN, FUNCTION VAR, SUBROUTINE INPUT, SUBROUTINE BIN and various Calcomp plotting routines.)

2. (U) SUBROUTINE HOROUT (X,Y,N) and SUBROUTINE RDIN1 (X,Y,N,IS, IU). These are general purpose utility routines that facilitate handling of floating point arrays between different computers. (Used here to transfer information between CDC 1604 and CDC 1700 computers and these routines are used on both machines.) HOROUT is used to write an array of N values of X vs. Y on a particular tape unit. The first record of a section of data contains the value of N as well as the minimum and maximum values of the array Y. Subsequent records contain eight values of X followed by eight values of Y alternately until N values of each are written. The tape format is in FORTRAN E-notation suitable for listing. RDIN1 is used to read in the data in the same format, i.e., N values of X and Y from unit IU and data section specified by IS.

3. (U) SUBROUTINEs CONVOUT (IX,IY,N), CONV, PACK, OUTBUF. These are a set of utility routines written for the CDC 1604 computer to produce binary tapes that are directly readable by the CDC 1700. Included is a conversion routine to convert CDC 1604 real numbers to CDC 1700 formatted real numbers.

4. (U) SUBROUTINE ENVGEN (F,N,FH,FL,FS,E). This subroutine generates the envelope E of N real values of data F given FH (the high frequency component), FL (the low frequency component) and FS (the sampling frequency). (This routine is also operational on the CDC 1604 computer.)

5. (U) FUNCTIONs XMAXIF (X,N), XMINIF (X,N), ABMAXF (X,N): generate the maximum, minimum, and absolute maximum of N values of real array X respectively.

6. (U) FUNCTION ERF11 (X,N): generates the error function integral of X and it indicates N, the number of terms used in the exponential expansion. The error function is defined by $E = \int_o^x e^{-t^{2/2}} dt$ and given X this function generates E accurate to about 10^{-5}.

7. (U) FUNCTION ERFINV (E): computes the inverse error function, i.e., given E this function returns X (see the integral above) accurate to about 10^{-3}.

8. (U) PROGRAM BCDPLT: a general purpose plotting routine that accepts BCD formatted tape (via RDIN1) of real numbers, scales the data by a given scale factor and optionally plots several sections of data on one set of axes.

9. (U) SUBROUTINE IMPLT (X,Y,N,XST,XINC,XLN,YST,YINC,YLN). This subroutine plots an impulse plot of N points of X vs. Y on the Calcomp plotter. The plot = XLN by YLN inches originating at point (XST, YST) with XINC and YINC as the X and Y increments per inch, respectively.

10. (U) SUBROUTINE CIRPLT (X,Y,N,XYMX). This subroutine produces a polar plot of 10 × 10 inches with maximum Y value being XYMX. It assumes that the X array is an angle measurement given in radians. The routine performs the transformation from cartesian to polar coordinates and produces the plot. For the use by this routine, the standard Calcomp AXIS subroutine was rewritten in order to allow axis divisions to be stepped off from maximum to minimum over the length of the axis.

11. (U) PROGRAM AMPSEC: computes the Fresnel integral. This program was used to check the Fast Fourier Transform of a waveform.

12. (U) SUBROUTINE CORREL (F,G,NF,NG,R): correlates real array F with real array G and stores the result in array R. NF is the number of values of F, NG is the number of values of G, and it is assumed that R is dimensioned to NF + NG − 1.

13. (U) FUNCTION CORRELF (TAU,G,TG,F,TF,NG,NF). This function assumes to have arrays of NG values of TG vs. G and NF values of TF vs. F and computes one step of a correlation of F with G assuming a displacement of amount TAU of TG relative to TF. The function value is the value of the correlation. (This function was also implemented on the CDC 1604 computer.)

14. (U) SUBROUTINE NEWTON (AC,N,R,RO): computes the root R of a given function F using Newton's method with RO as the initial estimate and to within specified accuracy AC. N is the number of iterations it takes to achieve the result. It is assumed that FUNCTIONs F and FPR are given, F as the function and FPR its derivative.

15. (U) SUBROUTINE SORT (X,K,N): sorts an array X of N real numbers in ascending order. K is a key integer index array that indicates the relative position of elements in the unsorted array so that arrays parallel to X can be sorted by simply addressing elements indirectly through K.

16. (U) FUNCTIONs IRDB (IO,K,IU) and IWTB (IO,K,IU). These are FORTRAN callable read and write routines, respectively. They read/write K binary words of array IO from/onto unit IU where IU is a magnetic tape unit. The function value is an indication of tape unit status at the completion of the operation.

17. (U) SUBROUTINEs BREAD (IU,IO,L,IFL) and BWRITE (IU,IO,L,IFL). These routines are the generalization of IRDB and IWTB respectively and are designed to include input/output from/onto the disk as well as the tape units. L is a three-word parameter array and IFL is the status indicator.

18. (U) FUNCTION MOTION (IU,ICODE): allows FORTRAN programs to have complete motion control of magnetic tape units such as rewind, backspace, advance to end-of-file, etc. The function value is an indication of tape unit status at the end of the operation.

19. (U) PROGRAM NOISE: generates a specified number of points of white noise (zero mean, unit variance) on the CDC 1604 computer with the aid of the standard random number generator and writes them on magnetic tape in standard FORTRAN E-format so that the white noise is accessible to the CDC 1700 computer.

20. (U) PROGRAM NARBNOIS was written for the CDC 1604 computer to generate narrow band noise by using white noise and cascading it through a triple stage digital filter. The format of output is the same as for the white noise (see above).

21. (U) SUBROUTINE MATINV (A,N,B,M,DET). This is an adaptation of a subroutine to the CDC 1700 machine that was written for the CDC 1604 computer. The subroutine performs the inversion of the N × N matrix A with accompanying solution of M columns of linear equations (optional). DET is the determinant of the matrix A.

2.2.2.1.2 **Digital Display** –

A. HARDWARE:

1. (U) A 32 circuit 0, +6 volt to 0, −12 volt output level shifter and cable driver has been built to adapt the CDC 1700 digital output voltage levels to the voltage levels required by the Modified Sonar Digital Display (MSDD) data and control lines.

2. (U) An input level shifter, originally intended to adapt time and sonar parameter logging code translator data to the voltage levels required by the ASDACS digital inputs, already exists and will be used for input data from the MSDD.

3. (U) Work remaining to be done on the ASDACS-MSDD INTERFACE includes:

(a) Building Input and Output cables to run between ASDACS and the MSDD;

(b) Including a self-contained power supply in the output level shifter and cable driver;

(c) Acquisition and installation of logic boards for two additional digital output words to be committed solely to the MSDD.

B. SOFTWARE:

1. (U) The following subroutines have been written and together make up a Fortran callable display generator and driver.

(a) SETBUF (IBUF,N): initializes a display buffer, IBUF, N words long in the calling routine.

(b) DLINE (X,Y,DX,DY): draws a vector starting at point (X,Y) with X deflection DX, Y deflection DY.

(c) CLINE (DX,DY): using the end point of the last vector as a starting point, draws a vector with X deflection DX, Y deflection DY.

(d) EVESET (XADJ,IEV,ISIZ): sets certain parameters used by the display to determine symbol size and type, and modify X position.

(e) STEXT (X,Y,ICODE,IB): draws one of 42 alphanumeric or special symbols determined by ICODE, at one of three brightness levels determined by IB, at a position (X,Y). Symbol size (full or half size available) is set by parameter ISIZ in EVESET.

(f) SPADE (X,Y,IAMP,IDOP): draws a sonar event symbol at positions (X,Y) where symbol type, length, and/or brightness is determined by IAMP and IDOP, modified by parameter IEV in EVESET.

(g) PICTUR: performs the cyclic output of the display buffer generated by the above subroutines to the MSDD.

2. (U) Test routines to checkout the above software and the MSDD and interface hardware have also been written.

3. (U) General purpose software work remaining to be done includes:

(a) A routine to perform input of data from the MSDD;

(b) Extension of the routine STEXT to provide the capability of outputing a message based on a Fortran format statement or an integer or floating point number;

(c) An executive routine to display a function list and, on the basis of inputs from the MSDD, select one of several processing and display routines.

2.3 Auxiliary Tasks

2.3.1 Travel

(U) Messrs. G. Turton and J. Teeter visited ARL, Sperry Corp., and SHIP OOVIC to discuss procedures for obtaining tape dubs of AN/SQQ-23 PAIR beamformed data during the week of 18 November, 1969.

2.4 Technical Reports Issued

1. Turton, G.A., "Problem Summary for SF-11-121-106/8132 for the Period from 1 January 1969 to 30 June 1969 (U)," NUC TN 283, September, 1969 (CONFIDENTIAL).
2. Teeter, J.L., "A Two Dimensional Target Model (U)," NUC TN 315, 10 December 1969 (~~CONFIDENTIAL~~). (U)

(U) REFERENCES

1. Olson, D., and J. Watring, "A Study of STARLITE Applications (U)," NUC TP 130, June 1969 (~~CONFIDENTIAL~~). (U)
2. Olson, D., "Operational and Tactical Considerations of Active Sonar Classification (U)," Proceedings of NAVSHIPS Symposium on Active Classification, Vol. I. Naval Postgraduate School, Monterey, California–3, 4, 5 October 1967 (~~CONFIDENTIAL~~). (U)
3. Teeter, J., "A Two Dimensional Acoustic Target Model (U)," NUC TN 315, 10 December 1969 (~~CONFIDENTIA~~L). (U)
4. Sperry Gyroscope, "Sonar Classification Feasibility Studies (U)," Contract No. N66001-69-C-0947, June, 1969 (~~CONFIDENTIAL~~). (U)
5. TURTON, G., "Problem Summary for SF-11-171-106/8132 for the Period 1 January 1969 to 30 June 1969 (U)," NUC TN 283, September, 1969.
6. Leiss, W., "Submarine Target Strength Summary - Part X (U)," Pennsylvania State University, ORL/TM-204.4611-11 (~~CONFIDENTIAL~~). (U)
7. Teeter, J., "Simulated Echoes for a Duel Array Sonar System (U)," NUC TN (to be published), (~~CONFIDENTIA~~L). (U)
8. Teeter, J., "Performance Analysis of Detectors for Active Sonar (U)," NUC TP 130, March, 1969 (~~CONFIDENTIAL~~)(U)